

SEA WATER GEOTHERMAL SYPHONING PURIFICATION, DESALINATION AND ELECTROLYSIS SYSTEM

TECHNICAL FIELD

[0001] The invention is broadly directed to a geothermal purification system. In particular embodiments, the invention provides a geothermal desalination and/or electrolyzed water production system.

BACKGROUND

[0002] There exists a considerable demand for disinfectant and sanitizing solutions throughout the world. The recent COVID-19 pandemic shed light on the need to disinfect and sanitize surfaces in order to prevent the spread of disease. Relatedly, the medical industry and households continue to need options for effective cleaning solutions. However, conventional cleaning solutions, like bleach, can be harsh on humans and require considerable resources to produce. For example, the chemicals in cleaning solutions can irritate skin, cause discomfort, and can even be deadly if accidentally consumed. Moreover, production plants for cleaning solutions require considerable use of electricity, water, and land.

[0003] Relatedly, people are becoming more environmentally aware and are seeking cleaner and greener products. Conventional cleaning solutions, while able to sanitize and disinfect, often have toxic byproducts that harm the Earth and require the use of large energy quantities. Toxic byproducts pollute waterways and often have negative effects on the human body.

[0004] Geothermal energy can provide limitless, zero-emission, baseload renewable energy, but drilling costs have historically made it expensive to do so, and restricted its use to locations where high temperatures are at shallow depth. People typically link geothermal power to countries such as New Zealand, Indonesia and the Philippines which are geologically active and where drilling to 2000 metres or less is sufficient to provide access to the high temperatures required to produce usable energy. However, it would be desirable to draw on geothermal energy to produce electricity and freshwater anywhere in the world.

[0005] Previous attempts at large scale geothermal energy development in Australia and other countries such as the USA have been thwarted by high drilling costs and both technological and environmental problems using conventional oil and gas drilling techniques. However, the ability to harness deep thermal heat and to utilise this energy to provide low cost electricity generation as well as desalination of sea water, heating, cooling or pumping with or without the

- 2 -

need or use of electricity, is highly desirable.

[0006] Zero-emission electricity can also produce valuable by-products like brine, high quality salt, potash and other minerals.

[0007] The present invention was conceived with these shortcomings in mind.

[0008] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present invention, a limited number of the exemplary methods and materials are described herein.

SUMMARY OF THE INVENTION

[0009] The present disclosure relates to systems and methods for electrolysed water production utilizing the sea water thermal syphoning energy system, the enhanced thermal syphoning system or the single or multi well geothermal syphoning systems as described in International Application Number PCT/AU2021/050743, the entirety of which is incorporated by reference herein.

[0010] In a first aspect, the present invention provides a geothermal electrolysis system, comprising; a salt water intake to receive salt water from a salt water source; one or more geothermal well(s) to heat the salt water to produce heated salt water; a desalination plant comprising one or more desalination chambers for separating salt from the heated salt water to produce at least some fresh water; an electrolysis plant connected to the desalination plant and receiving a salt brine by-product from the desalination plant, wherein the electrolysis plant is configured to electrolyse the salt brine by-product to create electrolysed water; and one or more discharge outlets to discharge and store one or more of the products of the electrolysis system.

[0011] The salt water may be sea water. The salt water intake may be a deep salt water intake, to receive cool salt water from the salt water source.

[0012] The geothermal well(s) in the system may further comprise a well inlet to receive salt water from the salt water intake into the geothermal well(s) and a well outlet to return heated salt water from the geothermal well(s) or the one or more discharge outlets comprise at least one fresh water outlet to discharge the fresh water.

- 3 -

[0013] The system may further comprise that the flow of the salt water in the geothermal electrolysis system is sustained by a thermal syphoning effect of the geothermal well, drawing salt water into an inlet of the geothermal well(s) at a first temperature as heated liquid is forced out of a well outlet of the geothermal well(s) at a second temperature, greater than the first temperature.

[0014] The system may further comprise a saline return for a saline output from the desalination plant, and the one or more discharge outlets comprise a salt water discharge to return the saline output to the salt water source.

[0015] The one or more discharge outlets may comprise at least one fresh water outlet to discharge the fresh water.

[0016] The system may further comprise a heat exchanger to heat the salt water from the salt water intake and cool the saline output from the desalination plant, prior to discharge of the saline output to the salt water source.

[0017] The heated salt water in the system is subject to pressure change in the one or more desalination chambers to separate salt from the heated salt water.

[0018] The system may further comprise a start-up pump to initiate flow of the salt water through the geothermal electrolysis system.

[0019] The system may be an onshore geothermal desalination system or an offshore geothermal desalination system.

[0020] The geothermal well(s) in the system may surrounding geology of between 200 and 250 degrees Celsius.

[0021] The temperature of the heated salt water exiting the geothermal well(s) may be between 90 and 120 degrees Celsius.

[0022] In the system one of the geothermal well(s) may reach surrounding geology of greater than 300 degrees Celsius, and preferably up to 500 degrees Celsius.

[0023] In the system the temperature of the heated salt water exiting the geothermal well(s) may be greater than 250 degrees Celsius, and preferably 280 degrees Celsius or higher.

[0024] In the system the temperature of the heated salt water may be between 90 and 120

- 4 -

degrees Celsius when it enters the first of the one or more desalination chambers.

[0025] The system may further comprise a saline output to produce salt from a saline discharge of the one or more desalination chambers.

[0026] The system may further comprise a power plant to generate electricity from thermal energy of the heated salt water, or wherein the power plant is driven by the thermal syphoning effect of the geothermal well(s).

[0027] In the system the power plant is driven by at least one pump, wherein the pump is part of a separate circuit that is driven by a thermal syphoning effect of at least one separate circuit geothermal well(s).

[0028] In the system the electrolysis apparatus may be driven by electricity produced by the power plant.

[0029] In the system the system may be pump free other than optionally a start-up pump.

[0030] The system may further comprise one or more pumps to assist the thermal syphoning process, driven using thermal energy from the heated salt water.

[0031] The flow of the salt water in the geothermal desalination system may be sustained by a thermal syphoning effect of the geothermal well(s), drawing salt water into an inlet of the geothermal well(s) at a first temperature as heated liquid is forced out of a well outlet of the geothermal well(s) at a second temperature, greater than the first temperature.

[0032] The system may further comprise a cooling flow pipe to direct some of the salt water to the desalination plant prior to entering the geothermal well, whereby the salt water provides a cooling effect to assist separation of the salt from the heated salt water.

[0033] The production of electrolysed water may be according using any of the aforementioned systems.

[0034] In a second aspect, the invention provides a method of geothermal electrolysis comprising: drawing salt water from a salt water source into one or more geothermal well(s) via a salt water intake; heating the salt water using the geothermal well(s); passing the heated salt water to a desalination plant for desalination of the heated salt water; and directing a brine by-product of the desalination plant to an electrolysis plant for electrolysis.

- 5 -

[0035] The method may further comprise discharging fresh water from the desalination plant.

[0036] In some embodiments, the fresh water may be discharged without the use of electricity or pumps.

[0037] The flow of the salt water in the geothermal desalination system may be sustained by a thermal syphoning effect of the geothermal well(s), drawing salt water into an inlet of the geothermal well(s) at a first temperature as heated liquid is forced out of a well outlet of the geothermal well(s) at a second temperature, greater than the first temperature.

[0038] The method may further comprise returning a saline output from the desalination plant to the salt water source or returning a saline output from the desalination plant to the salt water source without the use of electricity or pumps.

[0039] The method may further comprise cooling the saline output prior to returning the saline output to the salt water source, or heating the salt water from the salt water intake simultaneously with cooling the saline output using a heat exchanger.

[0040] The method may further comprise using thermal energy from the heated salt water to produce electricity.

[0041] The method may further comprise using the electricity produced to electrolyse the brine produced by the desalination plant to produce electrolysed water.

[0042] In some embodiments, the salt water may be heated in the geothermal well(s) from the surrounding geology.

[0043] Production of electrolysed water according may be using any of the aforementioned methods.

[0044] Additional comparisons with both wind and solar power shows geothermal energy to have a very small physical footprint, thus leaving surrounding land untouched, and available for alternative use. Additionally, this greatly reduces the environmental impact of the geothermal desalination and electrolysis system as there is no requirement for power lines, clearing of trees, no emissions and no toxic waste produced and the land above and around the geothermal bore can be rehabilitated after installation. Geothermal desalination, pumping, and electrolysis are also resistant to weather events and bush fire risk.

[0045] The present invention provides additional advantages in that there is minimal well or

- 6 -

pump maintenance required, no power line maintenance or power losses through long distance transmission, and no solar panels to dust. The use of steam engines and steam expanders has a long life and a track record for proven reliability, known examples operating for up to 100 years.

[0046] Once drilled and installed a single geothermal well will produce for hundreds of years while the well head flow can be controlled remotely.

[0047] The above advantages provide for significant reductions in typical desalination electrolysis costs, significant reductions in CO₂ emissions, and an increase in availability of green cleaning and sanitizing products.

[0048] From a safety perspective, the present invention also provides advantages in reducing (and in some cases eliminating) the use of dangerous electricity in the environment of water.

[0049] Geothermal desalination and electrolysis, driven from geothermal well energy systems using the thermal syphoning effect, does not produce the plastic waste that is normally generated by RO desalination plants. Additionally, these geothermal energy systems do not produce CO₂ emissions, do not produce toxic waste from the regular disposal of solar panels and wind turbine blades, do not require additional electricity generation and transmission for pumping, and have much lower negative impacts on the environment. It is calculated that a geothermal desalination and pumping system could produce fresh water up to 8 times cheaper than an RO desalination system whether driven from fossil fuel or electricity generated from solar, wind, or battery fed systems.

[0050] Various features, aspects, and advantages of the invention will become more apparent from the following description of embodiments of the invention, along with the accompanying drawings in which like numerals represent like components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0051] Embodiments of the invention are illustrated by way of example, and not by way of limitation, with reference to the accompanying drawings, which are briefly described below.

[0052] Figure 1 is a schematic view of an onshore geothermal electrolysis system according to an embodiment of the invention.

[0053] Figure 2 is a schematic view of an offshore geothermal electrolysis system according

- 7 -

to another embodiment of the invention.

[0054] Figure 3 is a schematic view of a geothermal desalination, pumping, and electrolysis system, illustrating a plurality of turbines for providing discrete mechanical outputs for driving the desalination process, a pumping process, and an electrolysis process simultaneously according to another embodiment of the invention.

[0055] Figure 4A is a cross-sectional view of a single well design of a geothermal syphoning well system.

[0056] Figure 4B is a cross-sectional view of a single well, well head of the geothermal well of Figure 4A, illustrating a series of cemented casing to protect the environment and to prolong well life, valves, insulated production casing, inlet and outlet flows and seals for controlling the flow of liquid into and out of the geothermal well.

[0057] Figure 5 is a schematic view of an electrolysis chamber in a geothermal electrolysis system according to an embodiment of the invention.

[0058] Embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which various embodiments, although not the only possible embodiments, of the invention are shown. The invention may be embodied in many different forms and should not be construed as being limited to the embodiments described below.

DETAILED DESCRIPTION

Onshore Electrolysis Systems:

[0059] With reference to Figure 1, there is illustrated a schematic view of a geothermal electrolysis system (100) according to an embodiment of the present invention. In this embodiment, the geothermal electrolysis system (100) is an onshore system and comprises a liquid pathway for salt water obtained from the sea by beach well (depicted) or by offshore, filtered sea water intake that is typical of a sea water intake system. The liquid pathway comprises a seawater intake (10) to draw in sea water. The sea water is then drawn through a heat exchanger (20) to a geothermal well (30), to heat the sea water. The heated sea water subsequently flows by thermal syphoning effect to a turbine (43), generator (46), and to a desalination plant (40) comprising one or more desalination chambers (42, 44). The turbine (43) may be a direct flash steam turbine where the hot sea water is flashed to produce fresh steam that is then used to drive the steam turbine to produce and store electricity in the generator (46).

- 8 -

Liquid may exit the liquid pathway in several ways, such as:

- as fresh water via a fresh water output (50),
- as salt water or brine through a saline output for the purposes of electrolyzed water production (60), for example using an electrolysis chamber (90), or
- via a salt water discharge (80) to return the salt water (or the brine, that is the saline output from the Desalination plant) to the sea.

[0060] In operation, sea water is received at the seawater intake (10), typically at around 10 to 20 degrees Celsius. It passes through heat exchanger (20), which, during operation, will typically heat the sea water to approximately 50 degrees Celsius. The geothermal well (30) draws the sea water in via a downward conduit, where it is heated by the surrounding geology and returned to the surface under pressure by the thermal syphoning effect. The heated sea water will generally be returned to the surface at approximately 90 to 120 degrees Celsius, depending on the depth of the geothermal well and the geological heat levels exposed by the geothermal well, in this embodiment of the invention. In this embodiment, the thermal syphoning effect can sustain movement of the liquid with minimal if any additional pumping requirements. The thermal syphoning effect, where liquid is heated by the surrounding geology of the geothermal well (30), results in cold seawater being taken in or drawn in at the seawater intake (10), and released from the geothermal well under pressure due to the heat received from the surrounding geology.

[0061] The hot sea water is delivered / pushed to the surface under pressure from the thermal syphoning effect, where it is used to drive a turbine (43) to generate electricity. As noted, the turbine (43) may be a direct flash steam turbine where the hot sea water is flashed to produce fresh steam that is then used to drive the steam turbine to produce and store electricity in a generator (46). Notably, in an alternate embodiment, the system (100) does not include a turbine (43) or generator (46), and, rather, the hot seat water is delivered / pushed to the surface under pressure from the thermal syphoning effect and directly into the desalination plant (40).

[0062] However, in this embodiment, after heat energy (thermal energy) is used from the hot sea water to generate electricity, it is passed / flows to the desalination plant (40) at approximately 120 degrees Celsius. The heated sea water is passed through the desalination plant (40), and fresh water separated by distillation from high saline brine. The brine or slightly saltier heated sea water itself will typically still be at around 50 to 70 degrees Celsius, after

passing through the Desalination plant (40).

[0063] The brine can be used for electrolysed water production (60). Specifically, the brine travels into an electrolysis chamber (90). Electricity (45) from the generator (46) supplies the electrolysis chamber (90). Once the brine is in the electrolysis chamber (90), the chamber (90) is activated and supplies a current to the brine.

[0064] As a result, the chamber (90) creates electrolysed water, which consists of an acidic solution (92) and an alkaline solution (91). Each solution (92, 91) then flows into its own respective storage tank. In alternate embodiments without a turbine (43) or generator (46), the electrolysis chamber (90) may be powered by a different electricity source.

[0065] However, some of the brine may also be returned to the ocean via the heat exchanger (20), where heat can be transferred to incoming sea water from the seawater intake (10). This serves the purpose of heating the sea water for optimum functioning of the geothermal well (30), but also to cool the saline water from 50 to 70 degrees to about 35 degrees Celsius, for minimal environmental impact when it is discharged via salt water discharge (80).

Alternate Embodiment: Electricity Generation - Organic Rankine Cycle 'ORC'

[0066] In an alternate embodiment, not pictured, the onshore electrolysis system differs from previous embodiments primarily in the incorporation of an Organic Rankine Cycle (ORC) to produce electricity to power the electricity chamber used in electrolysed water production. Specifically, a first heat exchanger may be included in the system to cool the hot sea water before being discharged back into the ocean and to also heat up the cold sea water being drawn from the ocean by the thermal syphoning effect in the geothermal well, to an optimum well intake temperature of approximately 50 degree C.

[0067] A second heat exchanger may be included in the system to heat up a secondary circuit fluid such as N-pentane. The ORC circuit fluid is turned into a gas as it flows through the second heat exchanger which is heated by the well circuit heated sea water. The gas is then used to drive a turbine that in turn drives an AC or DC electricity generator. A desalination plant is used in this system to cool and condense the N-pentane gas into a cooler liquid and the heat exchanged from the ORC fluid into the first desalination plant chamber is used to flash the injected sea water in a vacuum state, through 2 to 7 separate chambers, each chamber with increasing vacuum and lower temperature, dropping temperature by approximately 5 degree C in each chamber. Hot sea water is injected and discharged by thermal syphoning effect and the

- 10 -

fresh water produced by the Desalination plant is all delivered or flows under pressure by the geothermal syphoning effect with no requirement for electric driven pumps.

[0068] Moreover, like in the embodiment from Figure 1, the heated sea water is passed through the desalination plant, and fresh water separated by distillation from high saline brine. The brine or slightly saltier heated sea water itself will typically still be at around 50 to 70 degrees Celsius, after passing through the Desalination plant.

[0069] The brine is then used for electrolysed water production. Specifically, the brine travels into an electrolysis chamber. However, in this alternate embodiment, electricity created by the ORC circuit and stored in the generator supplies the electrolysis chamber. Once the brine is in the electrolysis chamber, the chamber is activated and supplies a current to the brine. As a result, the chamber creates electrolysed water, which consists of an acidic solution and an alkaline solution. Each solution then flows into its own respective storage tank.

[0070] However, some of the brine may also be returned to the ocean via the first heat exchanger, where heat can be transferred to incoming sea water from the seawater intake. This serves the purpose of heating the sea water for optimum functioning of the geothermal well, but also to cool the saline water from 50 to 70 degrees to about 35 degrees Celsius, for minimal environmental impact when it is discharged via seawater discharge.

[0071] Individual elements of the geothermal electrolysis system (100) are each described in more detail, later in this specification. However, it is useful at this point to provide an overview of alternative embodiments of the present invention, as shown in Figure 2.

Offshore Electrolysis Systems

[0072] Figure 2 provides a schematic view of an offshore electrolysis system (200) according to another embodiment of the invention. The offshore electrolysis system (200) comprises an offshore platform (210), to support various components of the system (200). In this embodiment, sea water intake (10) is provided as a conduit close to the ocean floor, to receive colder sea water directly into the geothermal well (30). The geothermal well receives / draws the colder sea water towards the bottom of the geothermal well where the surrounding geology has a natural temperature of 200 degrees Celsius or hotter, and then the thermal syphoning effect pushes the heated sea water to the surface, via insulated riser / production casing (220) or up additional connected geothermal wells with or without insulated riser / production casing to the surface under pressure.

- 11 -

[0073] In this embodiment, the sea water may be delivered to the surface, under pressure from thermal syphoning effect, at a delivered or production temperature of around 120 degrees Celsius, being lower than the original bottom hole geology temperature when the well was drilled and equipped, due to flow rates, heat losses through the insulated riser / production casing and to the cooling (cold front) of the deep geology over a period of 20 years or more of heat farming / production. When the heated sea water is pushed to the surface under pressure, the well head of the geothermal well or wells direct the high pressure, heated sea water towards and through it is used to drive a turbine (43) to generate electricity. The turbine (43) may be a direct flash steam turbine where the hot sea water is flashed to produce fresh steam that is then used to drive the steam turbine to produce and store electricity in a generator (46). Notably, in an alternate embodiment, the system (200) does not include a turbine (43) or generator (46), and, rather, the hot sea water is delivered / pushed to the surface under pressure from the thermal syphoning effect and directly into the Desalination plant (40).

[0074] However, in this embodiment, after heat energy (thermal energy) is used from the hot sea water to generate electricity, it is passed / flows to the desalination plant 40 at approximately 120 degrees Celsius. The heated sea water is passed through the desalination plant (40), and fresh water separated by distillation from high saline brine. Fresh water obtained from the desalination plant by multi effect distillation through 2 to 7 separate chambers where vacuum, (not depicted) also created by thermal energy and without requirement for electricity, in each chamber is adjusted to cause flash or vaporising of the injected sea water from each previous chamber until all traces of salt and minerals are removed from the water and the fresh water is then pushed by the geothermal well's thermal syphoning effect from the desalination plant where the pressurised fresh water can be piped to a fresh water market or customer without the requirement for electricity to pump the water or can be stored in fresh water storage tanks (51), before being output to a desired location via fresh water output (50).

[0075] The high saline brine or slightly saltier heated sea water itself will typically still be at around 50 to 70 degrees Celsius, after passing through the desalination plant (40). The brine can be used for electrolysed water production (60). Like in the onshore environment from Fig. 1, the brine travels into an electrolysis chamber (90). Similarly, electricity (45) from the generator (46) supplies the electrolysis chamber (90). Once the brine is in the electrolysis chamber (90), the chamber (90) is activated and supplies a current to the brine. As a result, the chamber (90) creates electrolysed water, which, again, consists of an acidic solution (92) and an alkaline solution (91). Each solution (92, 91) then flows into its own respective storage tank. In alternate embodiments without a turbine (43) or generator (46), the electrolysis chamber (90) may be

powered by a different electricity source.

[0076] However, some of the brine may also be returned to the ocean via a salt water discharge (80) fluidly connected to the desalination plant (40).

Alternate Embodiment: Electricity Generation - Organic Rankine Cycle 'ORC'

[0077] In an alternate embodiment, not pictured, the offshore electrolysis system differs from previous embodiments primarily in the incorporation of an Organic Rankine Cycle (ORC). In this embodiment, the inclusion of an Organic Rankine Cycle (ORC) electricity generation plant into the sea water thermal syphoning energy system powers the electrolysis chamber for electrolysed water production. This embodiment of the invention therefore includes an N-pentane circuit. N-pentane has a lower boiling point than water and is more suitable fluid or gas contained in a separate or secondary ORC circuit that is heated by the hot sea water at temperatures of 250 degree C and lower, that is flowing from one or more geothermal wells under pressure due to the thermal syphoning effect. The gas is then used to drive a turbine that in turn drives an AC or DC electricity generator. The desalination plant serves as a cooler and condenser for the ORC circuit gas after it is exhausted from the turbine. The ORC gas is converted to a cooler liquid and then as a liquid, the N-pentane is then heated and turned to a gas state by the heat exchanger that is heated by the geothermal well circuit again.

[0078] As with previous embodiments, the heated sea water is passed through the desalination plant and fresh water separated by distillation from high saline brine. The brine or slightly saltier heated sea water itself will typically still be at around 50 to 70 degrees Celsius, after passing through the desalination plant.

[0079] The brine is then used for electrolysed water production. Specifically, the brine travels into an electrolysis chamber. However, in this alternate embodiment, electricity created by the ORC circuit and stored in the generator supplies the electrolysis chamber. Once the brine is in the electrolysis chamber, the chamber is activated and supplies a current to the brine. As a result, the chamber creates electrolysed water, which consists of an acidic solution and an alkaline solution. Each solution then flows into its own respective storage tank.

[0080] However, some of the brine may also be returned to the ocean via the seawater discharge fluidly connected to the Desalination plant.

Simultaneous Desalination, Electrolysis, and Pumping Systems:

- 13 -

[0081] Figure 3 provides a geothermal desalination, electrolysis, and pumping system (300), comprising; a primary liquid circuit (1) circulating liquid (303) into a geothermal well (5) and returning heated liquid (304) from a well head (307) of the geothermal well (5), the primary liquid circuit (1) passing through a Desalination plant (340); a first turbine (310) driven by the heated liquid (304) to produce a first mechanical output (312) and a compressor (314) driven off the first mechanical output to provide a first compressed air supply (313) and a second compressed air supply (315), wherein the first compressed air supply (313) drives a supply pump (329) to supply salt water (316) to the desalination plant (340), and the second compressed air supply (315) drives a start-up pump (336) to initiate the primary liquid circuit (1); and a second turbine (310a) driven by the heated liquid (304) to produce a second mechanical output (312a), wherein the second mechanical output drives a fresh water pump (338), pumping fresh water from the desalination plant (340) to a delivery point (345).

[0082] Typically, the Desalination plant (340) will take around 20°C off the temperature of the heating or primary liquid circuit (1) as it passes through the first chamber (342) of the desalination plant (340). The larger the capacity of the desalination plant (340) the more heat required from the primary liquid circuit (1). Conversely, the smaller the capacity of the desalination plant (340), the less heat required from the primary liquid circuit (1). Accordingly, there is sufficient thermal energy in the heated liquid (304) heated by the geothermal well (5), to power the desalination plant (340), while simultaneously drawing off thermal energy and converting it to mechanical energy to drive a series of pumps (323, 329, 336, 338) and compressors (314) of the system (300).

[0083] A plurality of compressed air lines from the compressor (314) illustrated in Figure 3, can be configured to drive the start-up pump (336), the supply pump (329), and the brine pump (323) to feed brine (339) to an electrolysis chamber (343).

[0084] The fresh water pump (338) drawing the fresh, desalinated, water (320) from the fresh-water outlet (320) of the Desalination plant (340) and pumping it to the delivery point (345) can be driven: (i) directly by the second mechanical output (312a) of the second turbine (310a) as shown in Figure 3; (ii) by electricity generated by the turbine (310) and transmitted via mechanical output (312); or (iii) by compressed air generated by the compressor (314) driven by the turbine (310) and the mechanical output (312). The mechanical output (312) can be transmitted via a drive shaft.

[0085] The delivery point (345) for the fresh water (320) can be a dam, a reservoir, a pumping station, a pipeline, a plant, a vessel, a tank or the like.

[0086] In order to provide power for the additional components of the geothermal desalination, electrolysis, and pumping system (300) without the requirement for additional electricity, the heated liquid (304) (which can be water) is channelled through the first flash separator (325) where the pressure is reduced in the separator (325) to instantly flash evaporate a portion of the vapour into steam (306), about 10%.

[0087] The steam (306) is then drawn off the top of the separator (325) to drive the first turbine (310). The turbine (310) is directly linked to the compressor (314) which is driven from the mechanical output (312) of the turbine (310). The compressor (314) then feeds the plurality of compressed air supply lines: first supply line (313) to drive the supply pump (329) as described herein; second supply line (315) to drive the start-up pump (336) to initiate the primary liquid circuit (1) when/if required; third supply line (331) to drive the brine pump (323) which pumps brine (bi-products of the desalination process) from the brine outlet (321) out of the Desalination plant (340) and into the electrolysis chamber (343); and fourth supply line to drive the circuit pump (336) to initiate circulation in the secondary circuit (2).

[0088] In this embodiment the second supply line (315) drives a generator (346), which then produces electricity for the electrolysis chamber (343). When the electrolysis chamber (343) receives the brine from the brine pump (323), the electrolysis chamber (343) runs an electric current through the brine to produce electrolysed water (341).

[0089] Supply pump (329) is illustrated in proximity to the desalination plant (340) in the schematic view of Figure 3; however, as described herein the supply pump (329) is physically located deep within the salt water bore (not shown) and can be distanced from the Desalination plant (340) by some 10 kms or more.

[0090] After exiting (exhausting from) the turbine (310) the still hot exhaust (309) in the form of vapour (306) and/or heated liquid (304) is reintroduced and mixed back into the primary liquid circuit (1).

[0091] After flashing, the un-flashed liquid of the primary liquid circuit (1) exits the separator (325) via the drain (not shown). This un-flashed residual heated liquid (308) is mixed with the exhaust (309) of the turbine (310) before being directed to a secondary flash separator (325a). Again the exhaust (309) and the residual heated liquid (308) fed to the secondary separator (325a) is reduced in pressure on entry to the separator (325a) causing about 10% of the liquid to immediately evaporate into vapour or steam (306a). The vapour (306a) is channelled to the secondary turbine (310a) which generates the secondary mechanical output (312a) to drive the

freshwater pump (338).

[0092] The exhaust (309a) of the secondary turbine (310a) is reintroduced to the primary liquid circuit (1) and mixed with the residual heated liquid (308a) from the secondary separator (325a) before being fed to the Desalination plant (340) at a temperature of about 95°C. Specifically, the primary liquid circuit (1) after passing through each of the separators (325, 325a) and each of the turbines (310, 310a) is fed to the first chamber (342) of the Desalination plant (340) to evaporate the salt water (316) introduced thereto.

[0093] The freshwater pump (338) can be replaced with a compressor, but for large volumes of fresh water (320) a mechanical pump is preferred. The freshwater pump (338) will draw the fresh water from the fresh-water outlet (320) of the Desalination plant (340) and pump the fresh water to the predetermined delivery point (345).

[0094] Depending on the mechanical output required the skilled person can selectively substitute the above described turbines (310, 310a) for alternative machines, for example: direct stream turbines, ORC turbines, screw expanders, steam engines or the like.

[0095] Additionally, the compressor (314) can be selected from either screw compressors or piston compressors, where a screw compressor will be better suited to a large volume of fluid under lower pressure and a piston compressor will be better suited to larger pressures with less volume.

[0096] The geothermal desalination, electrolysis, and pumping system (300) may require a deeper geothermal well (5) depending on the geology of the area, to provide the additional thermal energy required to feed both turbines (310, 310a), before being introduced to the plant (340) at a sufficient temperature.

[0097] It should be noted that the geothermal desalination, electrolysis, and pumping system (300) can be configured to be located onshore or offshore.

[0098] Further details in relation to each of the individual features of the invention are described below.

Geothermal Well

[0099] A geothermal well (30) with bottom-hole geology temperatures of about 200 to 250 degrees Celsius, in Figures 1 and 2, is used to heat the salt water received via the salt water

intake (10). The thermal syphoning effect forces geothermally heated water to the surface as cold water is drawn into the well (30) to heat. The heated water from the well (30) is then forced or pushed from the well head outlet under pressure, towards the Desalination plant (40).

[0100] In other embodiments, deeper geothermal wells may be used, to reach bottom-hole geology temperatures of above 300 degrees Celsius, and in some cases up to 500 degrees Celsius. Deeper geothermal wells result in higher temperature sea water exiting the well, with more thermal energy which allows for the generation of electricity. In the future, when temperature ratings of suitable drilling tools are increased to drill in hotter than 500 degree Celsius rock temperatures, the geothermal wells may be drilled into hotter geology which would increase the production levels. Research and development of drilling tools developed by the present inventor is ongoing, and for example it is expected that by 2025, the heat rating of such drilling tools will manage rock temperatures up to 600 degree Celsius. Further details of such suitable drilling tools are provided below.

[0101] Sustainable production flow from single or multi well geothermal systems at a temperature of 200 degree Celsius and higher, may be used to drive an ORC turbine which in turn drives a DC or AC electricity generator for the generation of electricity which can be transmitted to a mains power grid, or to drive additional functionality of the geothermal desalination, electrolysis, and electricity system (100, 200, 300). For example, the electricity could be used to drive electrolysis (60, 340), or could be used to drive an air compressor to suck in ambient air to create a vacuum for the chambers of the Desalination plant (40). For generating electricity, the preferred sustainable production temperature of the heated salt water exiting the geothermal well (30) would typically be between 280 to 300 degrees Celsius for commercial viability or suitable returns on investment. Reliable and sustainable electricity can be generated from well production temperatures as low as 200 degree Celsius with electricity generation costs below \$0.03c per kWh and for periods beyond 20 years, however to finance a geothermal electricity generation system with these low levels of production, it would be difficult to attract investors compared to the production levels and investment returns that could be achieved with geothermal production temperatures above 250 degree Celsius. For embodiments where only desalination is required, temperatures of around 110 to 120 degrees Celsius (from a shallower well) would be suitable for very low-cost desalination and suitable returns on investment.

[0102] The geothermal well (30) and well head (32 - see Figure 2) are further described in relation to Figures 4A and 4B, which are substantially extracted from Australian Patent No. AU

2020101487, the entire contents of which are hereby incorporated by reference. Figures 4A and 4B illustrate only one well, although in some embodiments multiple geothermal wells could be used. The multi well thermal syphoning system (disclosed in PCT/AU2022/050864) will provide more efficient and higher production levels than a single well system equipped with insulated production casing. The single well system is shown in the drawings provided with this patent application to simplify the description and drawings, however in practice, the multi well geothermal syphoning well system will be used to provide higher production levels and stronger returns to investors and shareholders.

[0103] A single geothermal well (30) is illustrated in Figure 4A to provide a means for circulating liquid through the liquid pathway of the geothermal desalination system (100). It provides an inlet channel (annulus) (34) and insulated return channel (36) for supplying a heated salt water to the well head (32). The channels (34, 36) are arranged co-axially in tubing strings within the well (30).

[0104] Shown in Figure 4A, the well (30) includes a pipe inlet, a pipe outlet, the inlet channel (34) (first channel) and the insulated return channel (36) (second channel) disposed concentrically within the well 30. Although not illustrated, it is contemplated that the inlet channel (34) could be swapped with the insulated return channel (36) such that the inlet channel (34) is bounded and centrally located within the return channel (36).

[0105] The inlet channel (34) extends down the well (30) and receives liquid (i.e. salt water) from the pipe inlet and is defined between an outer casing and an insulated inner casing (37). The insulated return channel (36) is defined by the insulated inner casing (37) positioned within the outer casing. The insulated return channel (36) provides heated salt water to the pipe outlet at the surface.

[0106] Additional support casings (38, 38A, 38B) can be nested to extend the well downwards with a decreasing diameter. For example, a first support casing (38) may extend from the well head to a depth of around 100 metres, and have a diameter of approximately 30 inches (e.g. 75 to 80 centimetres). A second support casing (38A) may be positioned within, and may abut, the first support casing (38) and may extend from the well head to a depth greater than the first support casing (e.g. 500 to 700 metres). The second support casing (38A) may have a diameter of 18 5/8 to 20 inches (e.g. 45 to 55 centimetres). Further cascading support casings (e.g. 38B) may be positioned within the second support casings, to deeper depths and narrower diameters, as desired.

[0107] An outer casing (39) is positioned with the support casings (38, 38A, 38B) and defines a bottom of the well (30). The outer casing (120) may have a diameter of 12 to 14.5 inches. The outer casing (39) can be partially defined by the geological layers. In some embodiments the outer casing (39) may be consolidated rock such as granite that contains no groundwater, but has high levels of heat that will transfer into the salt water as it is drawn down the inlet channel (34) and comes into contact with the outer casing (39) of the well (30). A "closed-well" or sealed well arrangement prevents contact between the salt water and the geology surrounding the well (30). This "closed well" arrangement prevents sediment and other geological impurities from entering the liquid pathway of the salt water in the geothermal desalination system. However, it should be noted that such impurities can be extracted in the desalination plant (40) of the present invention during the production of fresh water.

[0108] The outer casing (39) of the well (30) will generally extend axially into the ground, but the depth may vary depending on the desired temperature of the surrounding geology. In some embodiments, the well (30) may extend to a depth of 4,000 to 5,000 metres, where typical geology temperatures (outside volcanic regions) are around 200 to 250 degrees Celsius. Alternatively, in other embodiments, the well (30A, 30B) may extend to a depth of approximately 8,800 to 12,000 metres, where surrounding geology temperatures in excess of 300 degrees Celsius can be reached. In most parts of Australia, the average temperature of the geology can be approximately 300°C in a 6,000 metre deep well. The specific depth, and surrounding geology temperature, may be selected by the skilled person to meet the thermal energy requirements of the particular geothermal desalination and/or electricity generation and/or hydrogen generation system.

[0109] Drilling to these depths may be effected by drilling technology such as drilling inventions designed by the present inventor, disclosed in Australian patent application nos PCT/AU2020/051060 ("Liquid Hammer Drill") and PCT/AU2021/051105 ("Centre Bypass Mud Hammer"), the entire contents of which are hereby incorporated by reference.

[0110] The heated salt water can flow out of the well (30) at a liquid flow rate of between 5 and 20 kg/sec at a temperature between 90 to 300 degrees Celsius from the insulated return channel (36), depending on the depth of the geothermal well (30). A deeper well (30A) can have a thermal energy output of between 5MWt-30MWt, for example 19.78 MWt can be achieved with a flow rate from the well head (32) of 20Kg/sec and temperature of 280°C where the initial well injection temperature is 50°C.

[0111] An expanded view of the well head (32) is shown in Figure 4B, which may include a

plurality of seals (51), an exterior support collar (52), and other features to provide proper support and outlet for of the well (30).

[0112] Thermal syphoning moves the liquid within the well (30) once the system begins flowing. In some embodiments, sea water at around 50 degrees Celsius (after passing through the heat exchanger (20)) is drawn down the well (30) where it is heated up on its journey to the bottom of the well (30) and then pushed to the surface inside of insulated production casing positioned in the centre of the well by casing centralisers and stabilisers. The increased temperature and the pressure created from the thermal syphoning effect, forces the heated salt or sea water up the return channel of insulated production casing (36) to the surface, or in the case with a multi well thermal syphoning energy system, up one to four additional wells connected to the injection well, with or without insulated production casing.

[0113] In one arrangement of the well (30) using a thermal syphoning system, a 300°C or hotter bottom hole geology temperature, the natural flow rate (without restriction by an adjustable valve at the wellhead outlet) out of a 6.0" ID insulated production casing at the surface could be 30kg/s or a velocity of 2 m/s. While the heated salt water may experience heat loss on the journey up the well (30), the outlet temperature will typically be 15 to 20 degree Celsius less than the liquid temperature at the bottom of the well (30).

[0114] The well (30) can be configured for a few thousand metres up to about 12,000m into almost any geology including granite. The depth of each geothermal well, being limited by the drill rigs capacity to lift the weight of the drill pipe and the temperature of the geology rather than the depth capacity of the CBMH drilling tools. The geothermal heat is exchanged at depth via a closed-loop system rather than bringing deep geothermal brine to the surface. This form of well (30) has a production life of 100+ years, with relatively low maintenance costs. The well (30) has a small physical footprint and has minimal impact on surface ground water systems, as the layers of casings around the well (30) provide protection.

[0115] In embodiments where the geothermal well (30) is located undersea, a blowout preventer (225) may be incorporated at the bottom of the insulated riser (220), to prevent blowouts that might result in the uncontrolled release of heated sea water from the well (30). The geothermal well can be abandoned or shut down without any risk of damage to the marine environment. When there is no temperature differentiation between the inlet temperature and the production temperature in the well, there will be no thermal syphoning effect and no flow into or from the well at all. The abandoned or shut down geothermal well will remain dormant with no risk of hot water flows until cool water is pumped into the inlet chamber to start the

thermal syphoning effect again.

[0116] It will be appreciated that the system may comprise multiple geothermal wells. For example, a multi-well arrangement is disclosed in application no PCT/AU2022/050864, by the same inventor, the entire contents of which are hereby incorporated by reference. The wells may be connected either above or below ground. In such an embodiment, one well (an injection well) may comprise a well inlet to receive the cool salt water, and another well (a production well) may comprise a well outlet to return heated salt water.

Salt Water Intake

[0117] The salt water intake (10) may be any suitable opening to receive salt water while filtering any contamination or sea life. The salt water is preferably cold, and in many embodiments will be sea water. Although the salt water intake (10) is primarily described in reference to sea water, and the sea is likely to be most commonly used water source, other sources of salt water may also be used (e.g. reservoirs or salt lakes). The salt water intake may comprise a simple conduit, with a filter (15), as depicted in Figure 2. Alternatively, it may comprise a beach well (12), with a beach well head (14) as depicted in Figure 1. The depth of the beach well (12) may vary, but in some embodiments the beach well (12) may be 20 to 50 metres deep. Beach wells are the preferred method of drawing sea water to a land based desalination plant, as the sea water is filtered by the sands and sediment as it is drawn by the thermal syphoning effect into the geothermal wells and the sea water being drawn from below the surface and low tide level will be cooler than sea water on the surface.

[0118] The temperature of the salt water may vary depending on the depth of the salt water intake (10) in the sea, and the geographical location of the geothermal desalination system. For example, water taken from deeper in the ocean will typically be colder than water taken from a shallower location. Similarly, sea temperatures may vary depending on geographical locations and seasons. Similar variations are possible in the salt content of the salt water.

[0119] Salt water is drawn into the salt water intake (10) via a geothermal syphoning effect, caused by the geothermal well (30). Operation of the geothermal well (30) is described in more detail in this specification. In some embodiments, an electric or thermal energy driven start-up pump may be used to initiate circulation of the salt water through the liquid pathway of the systems (100, 200, 300). However, once circulation is initiated, the thermal syphoning effect will maintain circulation of the liquid. Accordingly, in some embodiments, the geothermal desalination system may be substantially free from pumps, with the likely exception of an

electric or thermal energy driven start-up pump which can be used to initiate flow of liquid in the liquid pathway, before the thermal syphoning effect provides 100% of the pumping requirements for sea water intake, sea water discharge and fresh-water delivery. Once the thermal syphoning process begins there is little to no further requirement for pumping (i.e. zero to negligible energy input to keep the system running). Within a few minutes, the start-up pump can be turned off as the thermal syphoning effect will generate the flow and thermal energy production.

[0120] Although only a single salt water intake (10) is depicted in each of Figures 1 and 2, embodiments with multiple salt water intakes or bores are also possible, within the scope of the present invention. Multiple geothermal wells may be connected at the bottom of the wells by turning one well and then intersecting the horizontal section of the turned or steered well with one to four additional vertical wells, substantially as described in for example PCT/AU2022/050864 by the same inventor, the entire contents of which are hereby incorporated by reference.

Heat Exchanger

[0121] The heat exchanger (20) serves to heat salt or sea water from the salt water intake (10) prior to entry into the geothermal well (30), and also to cool salt water in the saline return (70) prior to discharge into the sea via salt water discharge (80). Reducing the temperature of the sea water discharge is preferred to reduce any impact that the hot sea water discharge may have on the marine environment. Increasing the temperature of the cold sea water intake will also improve the life and efficiency of the geothermal well system. A preferred intake temperature for sea water drawn into the well by thermal syphoning effect is between 50 and 70 degree Celsius.

[0122] An advantage of heating salt water to around 50 to 70 degrees Celsius is that it decreases the cooling effect of the colder salt water on the top sections of the geothermal well. If the top sections are cooled too much, this may reduce the temperature of the exiting heated salt water, and affect energy production (in electricity producing embodiments) or the efficiency of the desalination process.

[0123] An advantage of decreasing the temperature of the discharged saline water to around 35 degrees Celsius (or preferably between 30 and 40 degrees Celsius) is that it minimises the environmental impact of embodiments of the present invention, on the surrounding ecology.

Desalination Plant

[0124] A desalination plant (40, 340) is provided to separate salt from the heated salt water. In the embodiment of Figure 1, heated sea water is passed directly, along the liquid pathway, to the desalination plant (40) at a temperature of between 90 and 120 degrees Celsius. The desalination plant (40) contains multiple desalination chambers, including a first desalination chamber (42, 342) and last desalination chamber (44, 344). The sea water can be sprayed into each chamber of the plant (40) to be desalinated in stages therein.

[0125] The disclosed embodiments of the invention can use a multi-effect distillation (MED) plant, which uses distillation to desalinate sea or salt water. In each "effect" or "stage" of the multi effect distillation (MED) plant, salt water is sprayed onto tubes or plates made from titanium or stainless steel, heated by thermal energy inside of the tubes or plate heat exchangers that are position inside of the desalination chambers. Some of the saline water evaporates, and this fresh vapour is directed into the next chamber of the desalination plant to be sprayed onto the tubes or plates in the next chamber and so on until this process has been replicated – usually between three and seven times, in three to seven desalination chambers of the desalination plant with increasing vacuum or decreasing atmosphere pressure in each chamber, heating and evaporating more fresh water from salt water. Thus each stage reuses energy from the previous stage, with successively lower temperatures and pressures. For simplicity, three desalination chambers are shown in each desalination plant (40) depicted in Figures 1 and 2. However, different numbers of desalination chambers may be used in different embodiments of the invention. The temperature of the sea water usually reduces by 5 degree Celsius as it passes through each chamber. If the temperature of the sea water injected in the first chamber is 75 degree C after contact with the heat exchanger plate, and there are 7 chambers, the temperature of the fresh water outlet will be 45 degree Celsius.

[0126] The desalination plant (40) comprises a sequence of closed chambers separated by walls, having a hot fluid or steam heat source at a first chamber the same fluid with reduced heat (condensed) exiting from the first chamber. Each successive chamber has a temperature and a pressure lower than a previous chamber. For example, the temperature may decrease by about 5 degrees Celsius between each desalination chamber. This means the walls within each chamber are held at a temperature intermediate the temperatures of the fluids on either side thereof. This temperature differential, coupled with a pressure drop or increased vacuum in the chamber, transfers evaporation energy from a warmer first zone of the chamber to a colder second zone of the chamber. From the second zone the heat energy then travels via

conduction (and/or piping) through the wall to the colder subsequent chamber. Additional salt water can also be sprayed into the subsequent chambers to continue the effect through each chamber of the desalination plant (40).

[0127] In the embodiment of Figures 1 and 2, the salt water enters the first chamber of the desalination plant (40) that has a heat source of about at about 120 degrees Celsius, but the temperature of the vaporised water will be approximately 75 degree C after coming into contact with the heat plate. In other embodiments, where the salt water is heated to higher temperatures (e.g. 280 degrees Celsius or higher) by the geothermal well, the thermal energy may be used to generate electricity (see later description), thereby cooling the salt water to around 120 degrees Celsius before it enters the desalination plant. Variations on these temperatures are possible in different embodiments.

[0128] The desalination plant (40) has two main outlets. Firstly, there is a fresh water outlet. Secondly, there is a brine outlet, where the brine may be discharged through a saline output for subsequent electrolysis to make electrolysed water (60), or may be transferred via a sea water return (70) to eventually be returned to the sea via salt water discharge (80). It should be noted that the brine from the desalination plant may also be used for other downstream processes, or harvested for desirable commercial properties. For example, the waste brine can be evaporated in evaporation ponds to produce salt, pot ash, magnesium, lithium and other minerals at very low cost compared to current mining process for these minerals. These products can be sold to farmers for fertilising requirements and to the public for consumption and a wide range of other requirements.

[0129] The fresh water may be intermediately stored in a fresh water storage tank (51), particularly in offshore embodiments (200), or may be directed a pipe line or a collection point for use/collection.

[0130] In order to run the desalination plant (40), a drop in pressure is desirable between subsequent chambers of the plant (40). To achieve this vacuum in each chamber, a vacuum pump can be driven by waste thermal energy instead of by electricity. In electricity-generating embodiments of the present invention, electricity may also be used to power a vacuum pump (not shown) to create a vacuum for the desalination chambers of the desalination plant (40).

[0131] It is calculated that for every million litres of salt water delivered to the desalination plant (40) approximately 400,000 litres of distilled or fresh water can be produced from fresh-water output without any CO₂ emissions, toxic waste or additional electricity load input and at

- 24 -

an operational cost per KL of around 10c per kl. This production cost is approximately 25 times lower than typical RO desalination costs per KL when electricity is used to pump sea water at high pressure through filters and to pump the fresh water away from the plant.

[0132] Whilst the geothermal desalination plant of the invention is described herein in relation to a desalination plant, it is contemplated that the invention can also be applied to a Reverse Osmosis (RO) desalination plant or a Desalination plant. The quality of the fresh water will be lower when reverse osmosis filtration is used to desalinate the sea water and plastic waste is generated as the filters are replaced regularly. The preferred method of desalination is MED due to the much higher quality of water, being boiler grade distilled water, that would normally have a production cost above \$5.00 per kl when electricity is used for the desalination process.

Electrolysis - Electrolysed Water Production

[0133] Figure 5 provides a schematic view of an electrolysis chamber in a geothermal electrolysis system. As seen in Figure 5, the electrolysis chamber (90) receives brine (93) from the desalination plant (40) via a brine line (94).

[0134] An electricity source (98) supplies a positive charge (+) to an anode (97) and a negative charge (-) to a cathode (96). The anode (97) and cathode (96) are separated by a diaphragm (95) - creating an anode subchamber (97) and a cathode subchamber (96). Once the electric charge (98) is applied to the brine (93) in the chamber (90), negative chlorine and hydroxyl ions flow to in the direction of the anode, and positive hydrogen and sodium ions flow in the direction of the cathode.

[0135] As a result, after the electric charge (98) is complete, the anode subchamber (97) contains an acidic solution, and the cathode subchamber (96) contains an alkaline solution. In the art, the resulting alkaline solution and acidic solution are known as electrolysed water.

[0136] It should be noted that the diaphragm (95) is a semi-permeable membrane that allows the aforementioned flow of ions, acting as a separation barrier between the anode (97) and the cathode (96). Moreover, in some embodiments, the diaphragm (95) comprised of a polymer electrolyte membrane (PEM), but it can vary by embodiments. Relatedly, the anode (97) and cathode (96) consist of conductive materials that are low cost and resistant to rusting. For example, in some embodiments, the cathode (96) may be comprised of stainless steel, nickel alloys, or platinum, but the composition of the cathode (96) may vary. Regarding the anode (97), it may be comprised of graphite, but the composition of the anode (97) may vary.

- 25 -

[0137] It should be noted that in alternate embodiment, a person skilled in the art may use a different electrolysis chamber to produce electrolysed water.

[0138] Electrolysed water provides a non-toxic and safe alternative to harsh chemicals. Electrolysed water is made by running an electric charge through a water and salt mixture in an electrolysis chamber. The output is an acidic solution and an alkaline solution, with no toxic byproducts. The acidic solution serves as a strong disinfectant and sterilizer solution. On the other hand, the alkaline solution serves as a strong cleaner and degreaser.

[0139] Electrolysed water is safe on human skin while also having antimicrobial and anti-viral properties. More importantly, electrolysed water is not toxic to humans. As a result, exposure to electrolysed water does not pose a risk to humans, whether it is through accidental consumption or through runoff into waterways from the production process. As such electrolysed water (alkaline and acidic solution byproducts of electrolysis) provides an effective alternative to conventional cleaners that is safer and greener.

[0140] However, producing electrolysed water requires using electricity. Electricity production can have a large environmental footprint, often requiring the use of non-renewable resources like oil. Also, while alternatives like solar and wind energy have low emissions, they cannot presently deliver affordable baseload electricity needed for electrolysis. The production of electricity by way of geothermal wells disclosed herein provides clean and efficient alternative to drive electrolysis and electrolysed water production.

Specific Terminology

[0141] The term "*well*" has been used herein to refer to a deep geothermal wellbore providing thermal energy from hot geology to power the system. For clarity, the term "*bore*" has been used herein to refer to a salt water wellbore or beach well, providing salt water to the desalination plant. The technical terms bore and well can be used interchangeably, and have been used selectively herein in relation to the geothermal *well* and the salt water *bore*, merely for clarity.

[0142] While the term "*turbine*" is used herein to describe a machine that produces mechanical work by passing a fluid flow over a rotor or impeller to impart rotational motion thereto, it is understood that the "*turbine*" can be substituted for other mechanical devices, such as a steam engine, an Organic Rankine Cycle (ORC) turbine or a screw expander. Those skilled in the art will appreciate that different expanders are suitable for different power ranges and applications.

[0143] Although embodiments of the invention have been described with particular reference to the desalination of sea water, it will be understood that different sources of salt water (e.g. above or below ground water bodies, that may be or become hypersaline) are also suitable for desalination. It will also be understood that other embodiments of the invention may utilise other liquids, and/or may extract other types of impurities from those liquids.

[0144] Although good faith indications of the commercial efficiency of the present invention are provided below, these are provided for illustrative purposes, and the figures provided (e.g. the relative costs of desalinated water, or electricity) should not be taken as limiting, or as binding or limiting the present invention. The precise commercial utility of any particular embodiment will depend on numerous factors specific to that embodiment of the invention, and the commercial circumstances at the time.

[0145] It will be appreciated by persons skilled in the art that numerous variations and modifications may be made to the above-described embodiments, without departing from the scope of the following claims. The present embodiments are, therefore, to be considered in all respects as illustrative of the scope of protection, and not restrictively.

[0146] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present invention, a limited number of the exemplary methods and materials are described herein.

[0147] As used herein and in the appended claims, the singular form of a word includes the plural, unless the context clearly dictates otherwise. Thus, the references "a," "an" and "the" are generally inclusive of the plurals of the respective terms. For example, reference to "a feature" includes a plurality of such "features." The term "and/or" used in the context of "X and/or Y" should be interpreted as "X," or "Y," or "X and Y."

[0148] It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

[0149] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense,

- 27 -

i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

LEGEND

No.	Description	No.	Description
100	Onshore geothermal desalination system	92	Acidic solution
200	Offshore geothermal desalination system	93, 339	Brine
300	Geothermal desalination, electrolysis, and pumping system	94	Brine line
10	Sea water intake	95	Diaphragm
12	Beach well bore	96	Cathode
14	Beach well head	97	Anode
20	Heat exchanger	98	Electric charge
30	Geothermal well	303	Circulating liquid
32, 307	Well head	304	Heated liquid
34	Inlet channel	306, 306a	Vapour/Steam
36	Return channel	308, 308a	Residual head liquid
37	Insulated inner casing	309, 309a	Exhaust
38, 38A, 38B	Support casings	310, 310a	Turbine
39	Well outer casing	312, 312a	Mechanical output
40, 340	Desalination plant	313	First supply line
42, 342	Desalination chamber	314	Compressor
43	Turbine	315	Second supply line
44, 344	Last desalination chamber	316	Salt water
45	Electricity	321	Brine outlet
46	Generator	323	Brine pump
50, 320	Fresh water outlet	325, 325a	Flash separator

- 29 -

51	Fresh water storage tanks	329	Supply pump
60, 341	Electrolyzed water production	331	Third supply line
70	Saline return	336	Start-up pump
80	Salt water discharge	338	Fresh water pump
90, 343	Electrolysis chamber	345	Delivery point
91	Alkaline solution		

CLAIMS

1. A geothermal electrolysis system, comprising;
a salt water intake to receive salt water from a salt water source;
one or more geothermal well(s) to heat the salt water to produce heated salt water;
a desalination plant comprising one or more desalination chambers for separating salt from the heated salt water to produce at least some fresh water;
an electrolysis plant connected to the desalination plant and receiving a salt brine by-product from the desalination plant, wherein the electrolysis plant is configured to electrolyse the salt brine by-product to create electrolysed water; and
one or more discharge outlets to discharge and store one or more of the products of the electrolysis system.
2. The system of claim 1, wherein the geothermal well(s) further comprise a well inlet to receive salt water from the salt water intake into the geothermal well(s) and a well outlet to return heated salt water from the geothermal well(s) or the one or more discharge outlets comprise at least one fresh water outlet to discharge the fresh water.
3. The system of any preceding claim, wherein flow of the salt water in the geothermal electrolysis system is sustained by a thermal syphoning effect of the geothermal well, drawing salt water into an inlet of the geothermal well(s) at a first temperature as heated liquid is forced out of a well outlet of the geothermal well(s) at a second temperature, greater than the first temperature.
4. The system of any preceding claim, further comprising a saline return for a saline output from the desalination plant, and the one or more discharge outlets comprise a salt water discharge to return the saline output to the salt water source.
5. The system of claim 4, further comprising a heat exchanger to heat the salt water from the salt water intake and cool the saline output from the desalination plant, prior to discharge of the saline output to the salt water source.
6. The system of any preceding claim, wherein the heated salt water is subject to pressure change in the one or more desalination chambers to separate salt from the heated salt water.

- 31 -

7. The system of any preceding claim, further comprising a start-up pump to initiate flow of the salt water through the geothermal electrolysis system.

8. The system of any preceding claim, wherein the system is an onshore geothermal desalination system or an offshore geothermal desalination system.

9. The system of any preceding claim, wherein the geothermal well(s) reaches surrounding geology of between 200 and 250 degrees Celsius.

10. The system of any preceding claim, wherein the temperature of the heated salt water exiting the geothermal well(s) is between 90 and 120 degrees Celsius.

11. The system of any preceding claim, wherein at least one of the geothermal well(s) reaches surrounding geology of greater than 300 degrees Celsius, and preferably up to 500 degrees Celsius.

12. The system of claim 11, wherein the temperature of the heated salt water exiting the geothermal well(s) is greater than 250 degrees Celsius, and preferably 280 degrees Celsius or higher.

13. The system of any preceding claim, wherein the temperature of the heated salt water is between 90 and 120 degrees Celsius when it enters the first of the one or more desalination chambers.

14. The system of any preceding claim, further comprising a saline output to produce salt from a saline discharge of the one or more desalination chambers.

15. The system of any preceding claim, further comprising a power plant to generate electricity from thermal energy of the heated salt water, or wherein the power plant is driven by the thermal syphoning effect of the geothermal well(s).

16. The system of claim 15, wherein the power plant is driven by at least one pump, wherein the pump is part of a separate circuit that is driven by a thermal syphoning effect of at least one separate circuit geothermal well(s).

- 32 -

17. The system of any one of the claims 15 to 17, wherein the electrolysis apparatus is driven by electricity produced by the power plant.

18. The system of any preceding claim, wherein the system is pump free other than optionally a start-up pump.

19. The system of any preceding claim, wherein the system comprises one or more pumps to assist the thermal syphoning process, driven using thermal energy from the heated salt water.

20. The system of any preceding claim, further comprising a cooling flow pipe to direct some of the salt water to the desalination plant prior to entering the geothermal well, whereby the salt water provides a cooling effect to assist separation of the salt from the heated salt water.

21. The production of electrolysed water according using the system of claims 1 to 20.

22. A method of geothermal electrolysis comprising:
drawing salt water from a salt water source into one or more geothermal well(s) via a salt water intake;
heating the salt water using the geothermal well(s);
passing the heated salt water to a desalination plant for desalination of the heated salt water; and
directing a brine by-product of the desalination plant to an electrolysis plant for electrolysis.

23. The method of claim 23, further comprising discharging fresh water from the desalination plant.

24. The method of claim 24, wherein the fresh water is discharged without the use of electricity or pumps.

- 33 -

25. The method of any one of claims 23 to 24, further comprising returning a saline output from the desalination plant to the salt water source or returning a saline output from the desalination plant to the salt water source without the use of electricity or pumps.

26. The method of claim 25, further comprising cooling the saline output prior to returning the saline output to the salt water source, or heating the salt water from the salt water intake simultaneously with cooling the saline output using a heat exchanger.

27. The method of any one of claims 23 to 27, further comprising using thermal energy from the heated salt water to produce electricity.

28. The method of claim 28, further comprising using the electricity produced to electrolyse the brine produced by the desalination plant to produce electrolysed water.

29. The method of any one of claims 22 to 28, wherein the salt water is heated in the geothermal well(s) from the surrounding geology.

30. Electrolysed water produced according to the method of any one of claims 22 to 29.